T-992: Rad Hard Sensors for the HL-LHC
and
Silicon Strip telescope for the FTBF facility

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Overview

• The High Luminosity LHC (HL-LHC) will deliver an integrated luminosity up to 2500 fb^{-1} after 5 years

• At 5 cm from the interaction point the pixel detector will receive a dose of more than $10^{16} n_{eq}/cm^2$

• The current planar pixel technology cannot cope with such high radiation

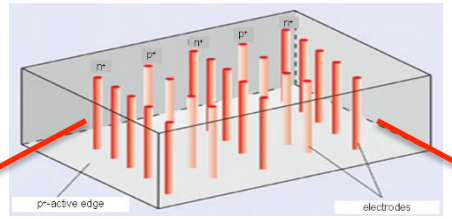
• The T992 collaboration is comparing different technologies that can withstand such high level of radiation:

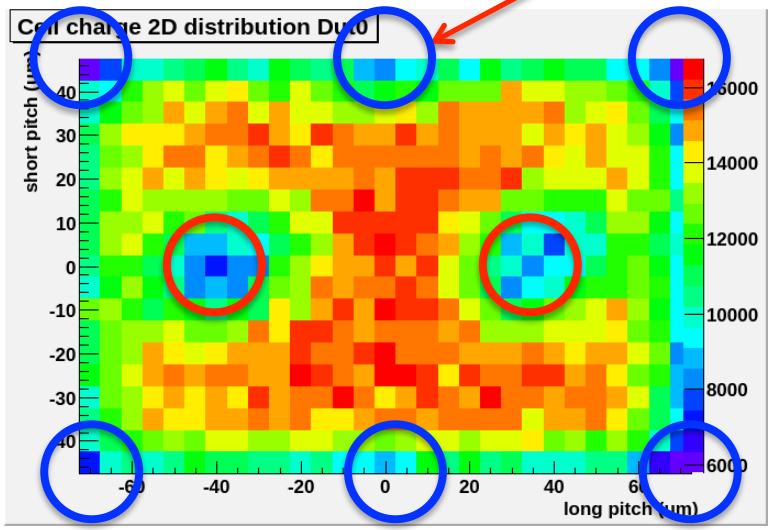
- 3D silicon (the electrodes are implanted in the bulk)
- Thin silicon (100-200 µm thick)
- Diamond (intrinsically rad-hard)

• We also tested the new digital CMS pixel Read Out Chip (ROC), the PSI46Dig

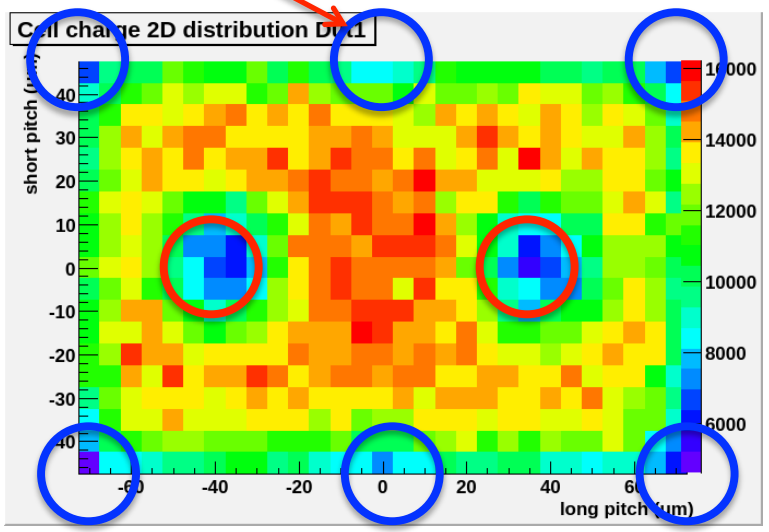
• A silicon strip plane for the next Silicon Strip Telescope

T992 quick summary results





SINTEF Not Irradiated

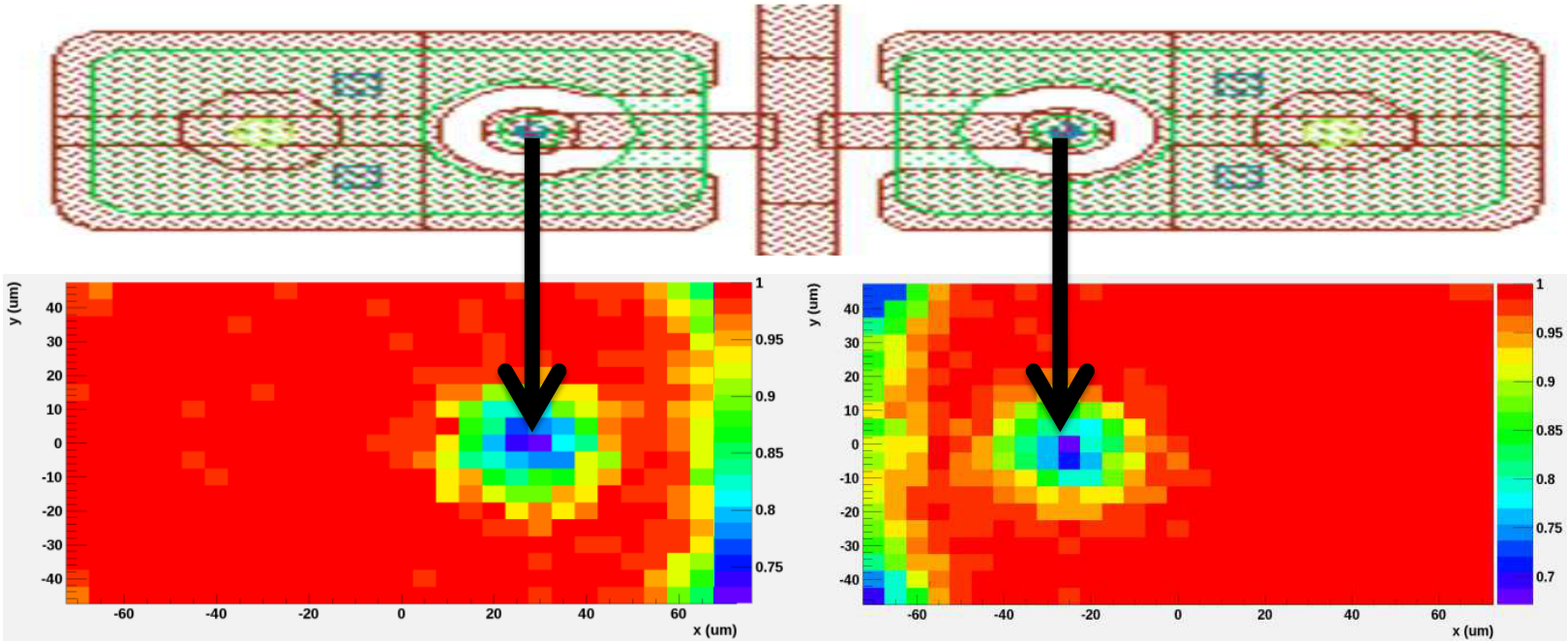


SINTEF Irradiated $1x10^{15}$

- Both detectors collect almost the same amount of charge and they both have an efficiency around 95% (the inefficiency is due to the electrodes)

- The irradiated detector is working really well but we still have to irradiate it by another factor of 10!

T992 quick summary results

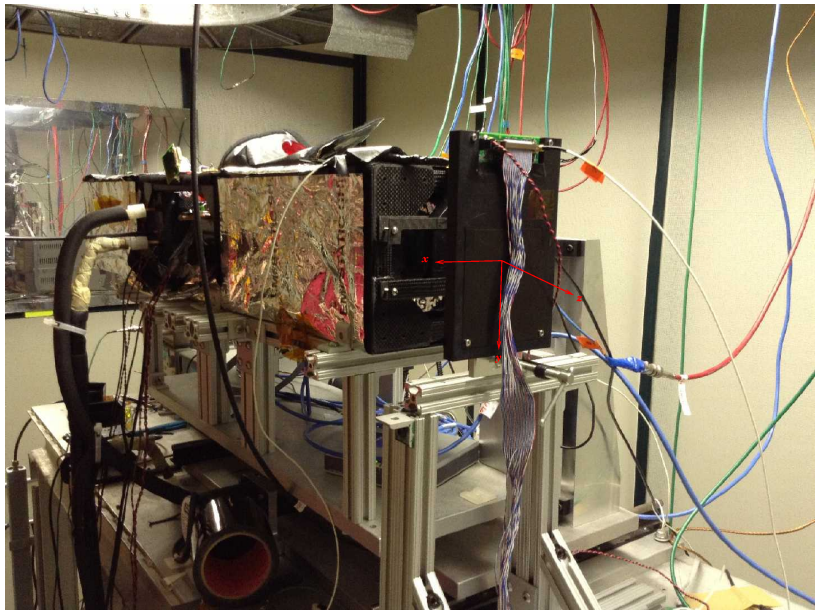


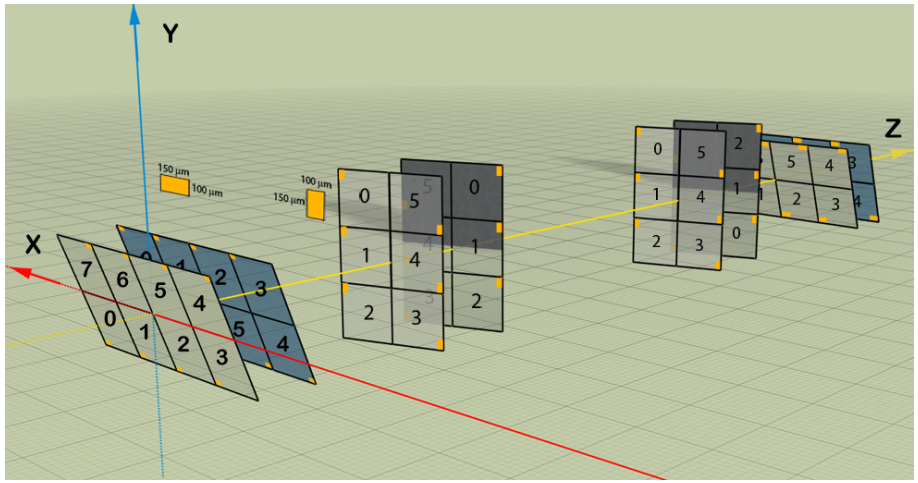
- Thin silicon sensors MCZ 200 µm thick

- Efficiencies above 96%

- Although the plot shows something very similar to 3D detectors, here there are not electrodes implanted in the bulk, and the detector is a regular planar one. The inefficiency here is caused by the bias distribution grid!

Pixel telescope



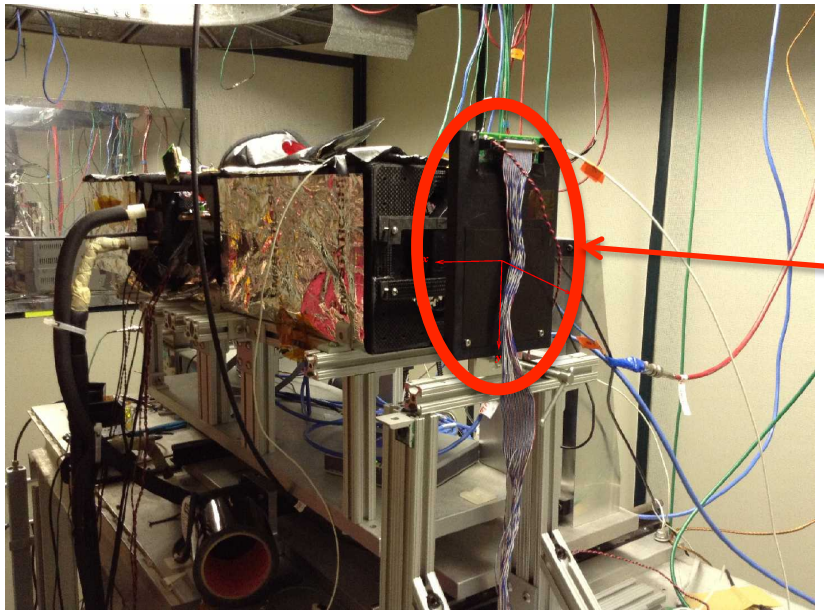


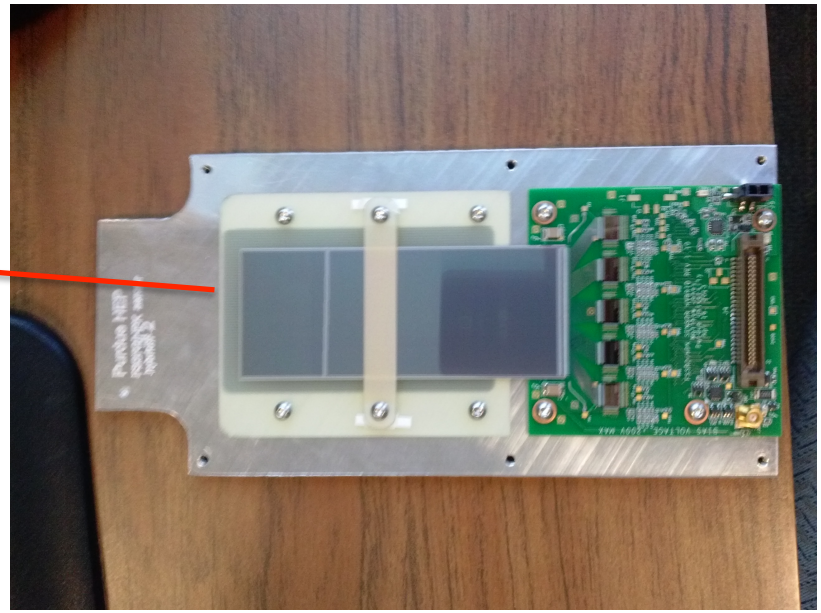
• 8 CMS pixel modules leftover from the CMS forward pixel production. 4 Modules have an area of 16.2 x 24.3 mm^2 and the other 4 have an area of 16.2 x 32.4 mm^2.

• The pixel cell has an area of 150 x 100 μm^2

• In order to achieve the resolution of ~6 µm we had to tilt the planes at a 25 degree angle, resulting in an overall overlap of about 14.6 x 14.6 mm^2. Big enough for our studies using a 120 GeV beam that can be squeezed to a sigma of ~6 mm, but actually too small for the many other experiments that used our telescope with beams of different particles and lower energies that are typically few cm wide!

Silicon strip telescope

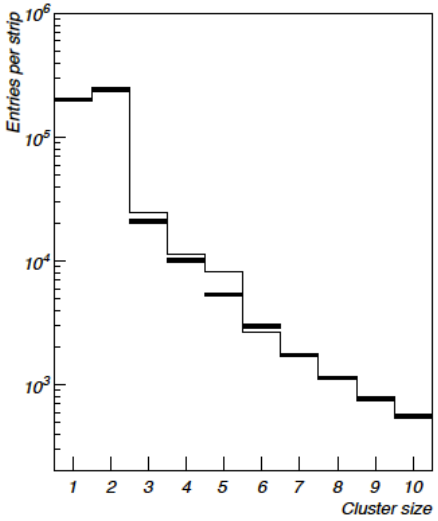


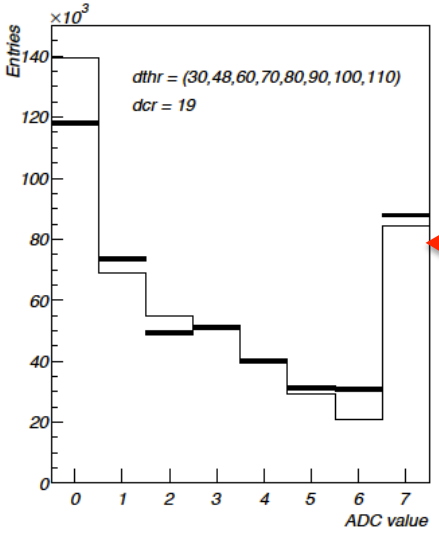


- We used the pixel telescope to test the first plane of the future Silicon Strip Telescope (SST)!
- The SST will have a coverage between ~36 x 36 mm^2 which is almost 6 times than the current pixel telescope coverage.
- The uncertainty in the area comes from the fact that the goal of this test beam was to understand at which angle we should tilt the planes, if we really have to!
- The strips are the Hamamatsu silicon sensors for the D0 Run IIb given to us by Ron Lipton and they are very good quality. The pitch is 60 µm.
- The ROCs are the FSSR2 chip that should have instrumented the BTeV strip detector.

Since everything worked really well we are going ahead and will build 18 stations (8 measuring X, 8 measuring Y and 2 UV stations for disambiguation)

Silicon strip telescope





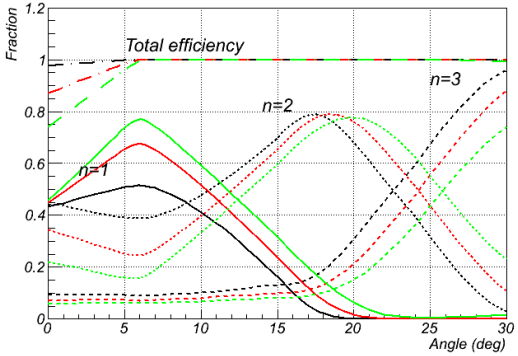
- We are comparing the data collected with Geant4 simulations to find out what is the angle that will give us the best resolution!

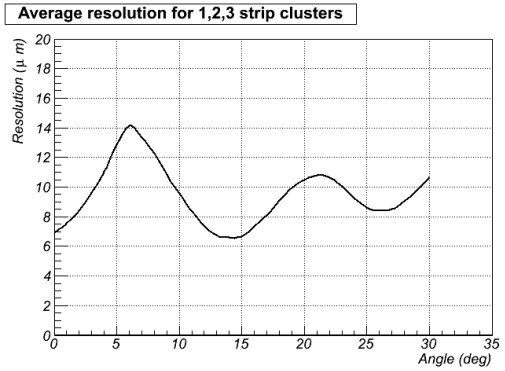
- In black we have the data which are matching well with our simulation (the underneath histograms)

On the right we have the simulated efficiency and clusters relative percentages for different thresholds.

With a 3 bit ADC it seems that we need to tilt the planes at least at 15 degrees to maximize the number of clusters of size 2 and 3 that can give a better position measurement.

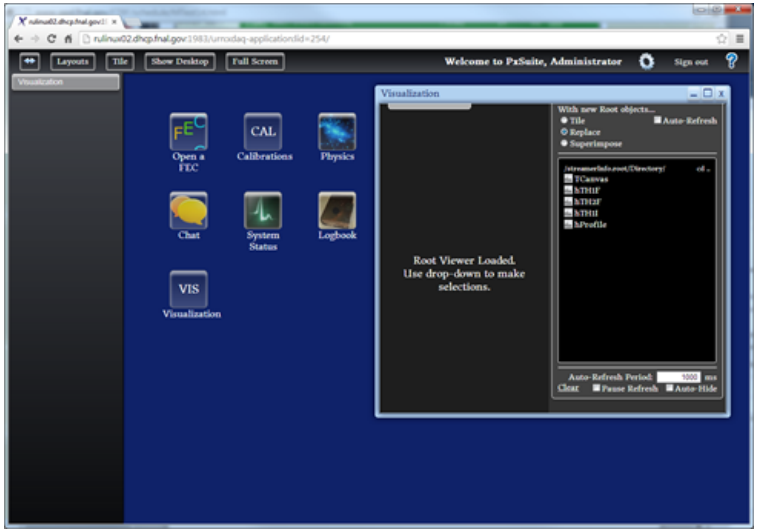
With an 8 μm resolution per plane we should be able to achieve a ~3 μm resolution both in X and Y in the middle of the telescope

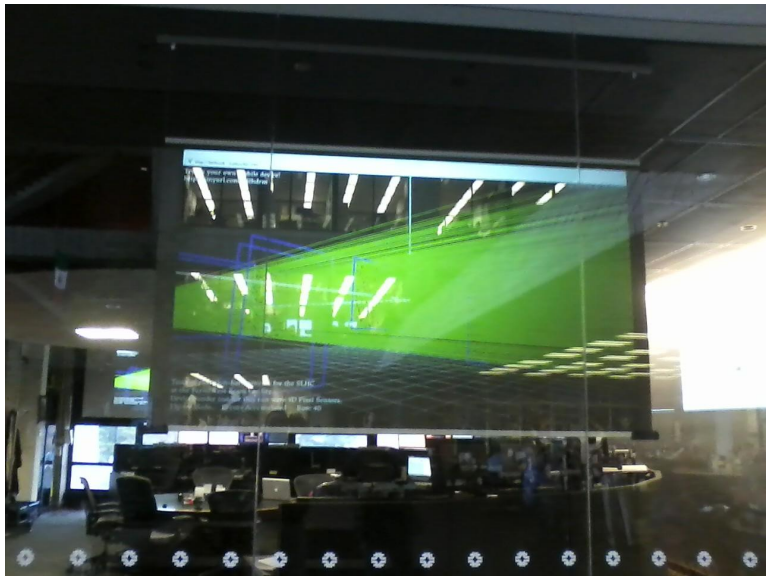




Silicon strip telescope software

• The ESE group is currently developing the software which is already in an advanced state and has been used to collect the data during this past November run from the SST plane. It is based on XDAQ which is the framework used by CMS and is basically a web server that allow to build a web based Graphical User Interface.





• The Data quality Monitor is also a XDAQ web application based on WebGL and Root.
• The CMS ROC room featured our viewer last month showing real data collected during the September run

• If you are connected to Fermilab network you can check it out live at:
http://ftbftracker01.fnal.gov:1983/urn:xdaq-application:lid=242/

Conclusions

- We have tested many different kind of sensors for the High Luminosity LHC upgrade

- We also successfully tested the new CMS pixel digital read out chip (100% efficient within the errors)

- We also have been successfully tested the first plane of the new Silicon Strip Telescope for the FTBF facility. The new telescope will have a much bigger area overlap (~6 times the present one) and will have a better resolution (~3 µm compared to the ~6 µm we have now)

- We are comparing the data to the simulations to finalize the mechanics

- We'll be back in January with more planes and build at least 4 to 6 stations by January 15th and then we'll build all the remaining planes by the end of January and finally complete the system!